THE METRIC SYSTEM.

THE

METRIC SYSTEM.

A COMPILATION,

CONSISTING OF EXTRACTS FROM THE REPORT OF THE COMMITTEE OF THE HOUSE OF REPRESENTATIVES, AND THE LAW OF CONGRESS ADOPTING THE SYSTEM, AND TABLES OF AUTHORIZED WEIGHTS AND MEASURES;

AND

A TRANSLATION

OF A PORTION OF A WORK ENTITLED

"THE LEGAL SYSTEM OF WEIGHTS AND MEASURES,"

By M. LAMOTTE,

PUBLISHED IN FRANCE FOR THE USE OF SCHOOLS, AND AUTHORIZED BY THE BOARD OF PUBLIC INSTRUCTION.

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INTRODUCTION.

EXTRACTS from the Report of the Committee composed of Charles H. Winfield, Thomas Williams, Hezekiah S. Bundy, Henry L. Dawes, John A. Kasson, Chairman, *appointed by the House of Representatives of the* 39*th Congress, for the Purpose of investigating the Metric System, and framing a Suitable Bill for its Adoption by Law.*

Your Committee unanimously recommend the passage of the bills and joint resolutions appended to this Report. They were not prepared to go, at this time, beyond this stage of progress in the proposed reform. The Metric System is already used in some arts and trades in this country, and is especially adapted to the wants of others. Some of its measures are already manufactured at Bangor, in Maine, to meet an existing demand at home and abroad. The manufacturers of the well-known Fairbanks scales state: "For many years we have had a large export demand for our scales with French weights, and the demand and sale is constantly increasing." Its minute and exact divisions specially adapt it to the use of chemists, apothecaries, the finer operations of the artisan, and to all scientific objects. It has always been and is now used in the United States coast survey. Yet in some of the States, owing to the phraseology of their laws, it would be a direct violation of them to use it in the business transactions of the community. It is therefore very important to legalize its use, and give to the people, or that portion of them desiring it, the opportunity for its legal employment, while the knowledge of its characteristics will be thus diffused among men. Chambers of commerce, boards of trade, manufacturing associations, and other voluntary societies, and individuals, will be induced to consider and in their discretion to adopt its use. The interests of trade among a people so quick as ours to receive and adopt a useful novelty, will soon acquaint practical men with its convenience. When this is attained, — a period, it is hoped, not distant, — a further act of Congress can fix the date for its exclusive adoption as a legal system. At an earlier period it may be safely introduced into all public offices, and for government service.

In the schedule of equivalents provided in the bill, extreme scientific accuracy is not expressed. The reasons follow. The exact length of the meter in inches, and the weight of the kilogram in grains, can of necessity be determined only approximately. The most careful determinations of these quantities now possible are liable to minute corrections hereafter, as more numerous observations are made, and better instruments are used. Instead, therefore, of aiming at an accuracy greater, perhaps, than is attainable, it is more expedient to consult the convenience of the people by using the simplest numbers possible in the schedule, and yet such as shall be in fact more nearly exact than can ever be demanded in the ordinary business of life. These numbers are to be used in schools, and in practical life millions of times as multipliers and divisors, and every unnecessary additional figure is justly objectionable.

In a popular sense of the word, however, the numbers in the schedule may be said to be exact. The length of the meter, for example, is given as 39·37 inches. The mean of the best English and the best American determinations differs from this only by about the amount by which the standard bar changes its length by a change of one degree of temperature. Such accuracy is certainly sufficient for legal purposes and for popular use.

The second measure recommended is a joint resolution, necessarily following the adoption of the leading bill, and provides for furnishing the standards which will thereby be required, to the several States.

The third proposition is a bill to authorize and provide for the use of the weight of 15 grams in the post-office, in conformity with the system adopted by that department for foreign correspondence.

The nomenclature, simple as it is in theory, and designed from its origin to be universal, can only become familiar by use. Like all strange words, these will become familiar by custom, and obtain popular abbreviations. A system which has incorporated with itself so many different series of weights, and such a nomenclature as "scruples," "pennyweights," "avoirdupois," and with no invariable component word, can hardly protest against a nomenclature whose leading characteristic is a short component word, with a prefix signifying number. We are already familiar with *thermometer*, *barometer*, *diameter*, *gasometer*, etc., with *telegram*, *monogram*, etc., — words formed in the same manner.

After considering every argument for a change of nomenclature, your Committee have come to the conclusion that any attempt to conform it to that in present use would lead to confusion of weights and measures; would violate the easily learned order and simplicity of metric denomination, and would seriously interfere with that universality of system so essential to international and commercial convenience.

When it is remembered that of the value of our exports and imports in the year ending June 30, 1860, in all $762,000,000, the amount of near $700,000,000 was with nations and their dependencies that have now authorized, or taken the preliminary steps to authorize, the metric system, even denominational uniformity for the use of accountants in such vast transactions assumes an important significance. In words of such universal employment each word should represent the identical thing intended, and no other, and the law of association familiarizes it.

BILLS AND RESOLUTIONS ACCOMPANYING THE REPORT.

A BILL *to authorize the Use of the Metric System of Weights and Measures.*

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That from and after the passage of this act, it shall be lawful throughout the United States of America to employ the weights and measures of the metric system; and no contract, or dealing, or pleading in any court, shall be deemed invalid, or liable to objection, because the weights or measures expressed or referred to therein are weights or measures of the metric system.

SEC. 2. *And be it further enacted,* That the tables in the schedule hereto annexed shall be recognized, in the construction of contracts, and in all legal proceedings, as establishing, in terms of the weights and measures now in use in the United States, the equivalents of the weights and measures expressed therein in terms of the metric system; and said tables may be lawfully used for computing, determining, and expressing in customary weights and measures the weights and measures of the metric system.

MEASURES OF LENGTH.

METRIC DENOMINATIONS AND VALUES.		EQUIVALENTS IN DENOMINATIONS IN USE.
Myriameter,	10,000 meters,	6.2137 miles.
Kilometer...	1,000 meters,	0.62137 mile, or 3,280 feet & 10 inches.
Hectometer,	100 meters,	328 feet and one inch.
Dekameter..	10 meters,	393.7 inches.
Meter.........	1 meter,	39.37 inches.
Decimeter...	$\frac{1}{10}$th of a meter,	3.937 inches.
Centimeter..	$\frac{1}{100}$th of a meter,	0.3937 inch.
Millimeter..	$\frac{1}{1000}$th of a meter,	0.0394 inch.

MEASURES OF SURFACE.

METRIC DENOMINATIONS AND VALUES.		EQUIVALENTS IN DENOMINATIONS IN USE.
Hectare......	10,000 square meters,	2.471 acres.
Are............	100 square meters,	119.6 square yards.
Centare......	1 square meter,	1550 square inches.

Measures of Capacity.

Metric Denominations and Values.			Equivalents in Denominations in Use	
Names.	No. of liters.	Cubic Measure.	Dry Measure.	Liquid or Wine Measure.
Kiloliter or stere	1,000	1 cubic meter.......	1.308 cubic yards..	264.17 gallons.
Hectoliter..	100	$\frac{1}{10}$th of a cubic meter	2 bus. & 3.35 pecks	26.417 gallons.
Dekaliter ..	10	10 cubic decimeters	9.08 quarts.........	2.6417 gallons.
Liter.........	1	1 cubic decimeter..	0.908 quart..........	1.0567 quarts.
Deciliter ...	$\frac{1}{10}$	$\frac{1}{10}$th of a cubic decimeter......	6.1022 cubic inches.	0.845 gill.
Centiliter..	$\frac{1}{100}$	10 cubic centimeters	0.6102 cubic inch.	0.338 fluid oz
Milliliter...	$\frac{1}{1000}$	1 cubic centimeters	0.061 cubic inch...	0.27 fluid drm.

Weights.

Metric Denominations and Values.			Equivalents in Denominations in Use.
Names.	Number of grams.	Weight of what quantity of water at maximum density.	Avoirdupois Weight.
Millier or tonneau..	1,000,000	1 cubic meter................	2204.6 pounds.
Quintal	100,000	1 hectoliter	220.46 pounds.
Myriagram	10,000	10 liters............................	22.046 pounds.
Kilogram or kilo ...	1,000	1 liter................................	2.2046 pounds.
Hectogram............	100	1 deciliter	3.5274 ounces.
Dekagram	10	10 cubic centimeters........	0.3527 ounce.
Gram	1	1 cubic centimeter	15.432 grains.
Decigram	$\frac{1}{10}$	$\frac{1}{10}$ of a cubic centimeter..	1.5432 grains.
Centigram	$\frac{1}{100}$	10 cubic millimeters........	0.1543 grain.
Milligram	$\frac{1}{1000}$	1 cubic millimeter...........	0.0154 grain.

JOINT RESOLUTION *to enable the Secretary of the Treasury to furnish to each State one set of the Standard Weights and Measures of the Metric System.*

Be it resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of the Treasury be, and he is hereby, authorized and directed to furnish to each State, to be delivered to the governor thereof, one set of the standard weights and measures of the metric system, for the use of the States respectively.

A BILL *to authorize the Use in Post-Offices of Weights of the Denomination of Grams.*

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Postmaster General be, and he is hereby, authorized and directed to furnish to the post-offices exchanging mails with foreign countries, and to such other offices as he shall think expedient, postal balances denominated in grams of the metric system, and until otherwise provided by law, one-half ounce avoirdupois shall be deemed and taken for postal purposes as the equivalent of fifteen grams of the metric weights, and so adopted in progression; and the rates of postage shall be applied accordingly.

THE LEGAL SYSTEM
OF
WEIGHTS AND MEASURES.

FROM THE FRENCH OF M. LAMOTTE.

ORIGIN OF THE METRIC SYSTEM.

TO measure is to ascertain how many times a quantity, which is taken as a term of comparison, or, in other words, as a *unit of measure*, is contained in another quantity, of which one wishes to know or represent the amount.

Thus, to measure the distance between two cities, is to ascertain how many times the unit of length, the *kilometer*, is contained in that distance. To measure a ton, is to ascertain how many times the unit of measure, the *liter*, is contained in the ton. To measure a piece of cloth, is to ascertain how many times the unit of measure, the *meter*, is contained in the length, &c.

If the inhabitants of every country had originally been able to act in concert with each other, and agree to employ everywhere the same measures, that understanding would have much simplified the transactions of commerce and industrial pursuits.

Unfortunately, this was not the case; and as, at first, communication between different countries was difficult and infrequent, a great number of different measures became established.

One can readily conceive the errors and frauds which resulted from this confusion of measures having different values and names.

At the end of the last century, the French Government undertook to establish throughout its territory one system of measures.

None of the measures in use could be adopted, for each province would have demanded preference for its own; and there was not then in France any system of measures sufficiently simple to merit being chosen to the exclusion of the rest.

As it was desirable that the new system of measures should obtain general favor, foreign countries were invited to join with France, in order to choose new units. A great number of scientific men, commissioned by Spain, Denmark, Tuscany, Switzerland, &c., met in Paris, to contribute their information to that of the scientific men of France.

The difficulty resolved itself into the question of choosing the new unit of *length*, and that of *weight:* from this double unit the system has been named *the system of weights and measures.*

Two Commissions of the Institute were charged with the operations necessary for determining these two units. The one, the Astronomical Commission, devoted itself to the unit of length; the other, the Commission of Physical Sciences, determined the unit of weight in relation to that of length.

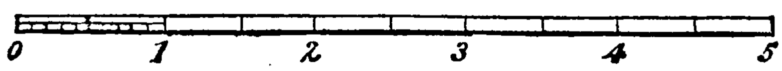
The first labors undertaken, at the request of the Government, for the establishment of a new system of measures, date from the 31st of March, 1791. But it was not until the 22d of June, 1799, that the scientific men charged with these operations had finally determined the *meter* and the *kilogram* units of measure for *length* and *weight*. This long delay had been caused by political troubles, which interrupted their labors for seven years.

If the measures employed up to that time, in different parts of France, did not seem worthy of preservation, it was because those measures had no relation to anything; whereas the relation of the *meter* to the *gram* has been determined by important operations which I shall presently describe. The new measures cannot disappear. Mankind is interested in preserving them as monuments of science.

The new system of measures is called the *metric system*, because the *meter* is its base. It is also called the *legal system*.

The word *legal* is not a useless title conferred on the new measures. The law enjoins the teaching of the metric system in all the schools, and its employment in all public acts. The metric system taught to all the youth in the schools cannot fail, like everything simple and clear, to triumph over the former routine.

MEASURES OF LENGTH.



THE METER.

THE *meter*, the new measure of length, represents a fraction of the terrestrial globe; and on this account alone its preservation is important to science, which will transmit it to posterity. I cannot here explain the great labors which have led scientific men to the knowledge of the dimensions of the terrestrial globe. I shall only remind the reader that the earth is a globe which revolves on its axis every twenty-four hours. The two opposite points on its surface, which remain fixed during this rotation, are named poles. The earth is divided into two hemispheres by the line called the equator; on which all points are equally distant from the two poles. The earth is not exactly round, but slightly flat at the poles, and bulging at the equator.

If one will recollect that buildings, forests, mountains, cover the surface of the earth, one can with difficulty realize the possibility of measuring its dimensions, as if they were those belonging to a smooth and regular body. But, compared with the size of the earth, the inequalities which cover its surface are not more appreciable than would be a speck of dust on the surface of an orange; and if we could place ourselves above the earth, and view it from a distance, we should recognize it as a perfectly even globe. Besides, all operations are referred to the level of the sea.

At the time mentioned, some mathematicians had already measured the dimensions of the earth in various directions; but before finally establishing the length of the new unit of measure, two able astronomers, Méchain and Delambre, were charged with repeating and continuing the operations already begun.

They measured a portion of the meridional arc between Dunkirk and Barcelona. Later, Biot and Arago were charged with measuring the prolongation of the meridian as far as the island of Formentara. They deduced from that, taken in connection with the measurement of a meridional arc formerly obtained in Peru, the distance from the pole to the equator. This length, divided by ten millions, furnished the *Meter*, the new unit of linear measures, and the basis of the metric system. *The meter is, therefore, the ten-millionth part of the fourth of the terrestrial meridian.*

The figure seen at the head of this chapter represents a fraction of the meter. That line is five centimeters in length. It must be made twenty times longer, to obtain the exact length of the meter.

A meter of platinum was deposited in the National Archives, to serve as a model, or standard, for the patterns which the Government distributed throughout the whole of France.

SUBDIVISIONS OF THE METER.

The length of a measure should be proportionate to that of the lines which are to be measured. Thus it would be inconvenient to state in meters the distance from Paris to St. Petersburg, because the number would be too large. For the same reason, one would not take a meter for the purpose of gauging the thickness of glass, because that thickness is too small a fraction of the unit.

To measure lines smaller than the meter, it is divided into ten equal parts called *decimeters*, that is to say, tenths of a meter.

The *decimeter* is also divided into ten equal parts called *centimeters*, that is to say, hundredths of a meter; because, as there are ten centimeters in a decimeter, and ten decimeters in a meter, there are one hundred centimeters in a meter

The *centimeter* is also divided into ten equal parts called *millimeters*, that is to say, thousandths of a meter.

To measure very minute lines, we again divide the *millimeter* into ten equal parts, or ten thousandths of a meter;—the ten thousandth of a meter into ten parts, or hundred thousandths;—the hundred thousandth of a meter into ten parts, or millionths.

Still, whatever the sum-total of the subdivisions used, it is advisable not to employ, at the same time, many various ones. Thus one should not say: A line of 6 decimeters and 4 centimeters; but as 6 decimeters are equal to 60 centimeters, one should say: A line of 64 centimeters. For the same reason, one should not say: A line of 4 centimeters and 8 millimeters, but: A line of 48 millimeters.

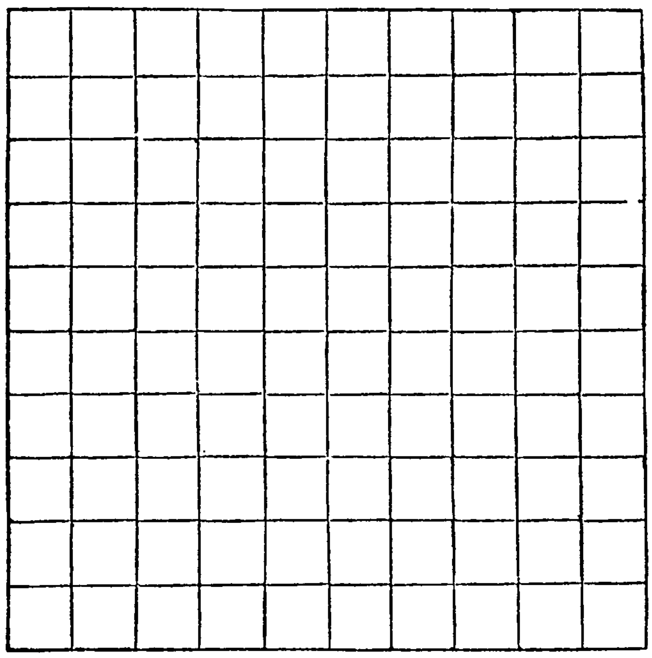
MULTIPLES OF THE METER.

Multiples of the meter are lines of several meters in length, derived in decimal order from the meter· Thus there are in common use,

The dekameter,	which is	equal to	10 meters.
The hectometer,	"	"	100 meters.
The kilometer,	"	"	1,000 meters.
The myriameter,	"	"	10,000 meters.

Just in proportion to the length and difficulty of calculations by the old measures are they easy with the new ones, owing to the facility of expressing every length in decimals.

MEASURES OF SURFACE.



THE SQUARE METER.

A *SQUARE* is a geometrical figure which has four equal sides and four right angles, as shown in the above drawing.

To measure a surface of any form, we find how many times it contains the surface of a smaller square adopted as the unit or term of comparison. The square chosen for the unit of measure should be proportionate to the size of the surface to be determined. For example, to measure the surface of a wall, it must be referred to the square meter, that is to say, to a square which is one meter long on each side; but to measure the size of a sheet of paper, instead of the square meter, the square decimeter is employed, that is to say, a square which is one decimeter long on each side.

Surfaces are not so easily measured as lines. To measure a line, it is sufficient to apply the meter and its subdivisions along the line as many times as the line will contain them; but to measure a triangular or a rounding piece of ground, the same means are not applicable; for the surface of such ground cannot be exactly covered by the various squares which may be taken as the units of measure.

Yet, whatever the form of the surface to be measured,—rectangular, triangular, circular, or oval,—it is evident that this surface is equivalent to a certain number of times that of the square taken for the unit of measure. It is only necessary to know the rules of Geometry, to ascertain, in squares, the value of surfaces of any form.

To ascertain, in square meters, the surface of a rectangle, the geometrical rule is to find how many meters there are in the length and in the breadth, and to multiply the two numbers together. Thus, if the length in meters is $\overset{m.}{20.}\,33$, and the breadth in meters is $\overset{m}{8.}\,3$, the surface measurement would be expressed by the product, $\overset{m.}{168.}\,739$ meters; that is to say, it would contain 168 square meters and 739 thousandths of a square meter. So, also, to measure, in square meters, the surface of a circular basin, the radius of the basin must be measured with the meter, the number obtained multiplied by itself, and this product by 22, and the result divided by 7.

My intention is not to demonstrate either these rules or others which Geometry prescribes for the measurement of surfaces. They are given in treatises on Geometry, to which it is necessary to refer for information. I wish only to designate the different surface-measures in use in the metric system. These measures are:

The *square meter*, or square whose side is one meter long.

The *square decimeter*, or square whose side is one decimeter long.

The *square centimeter*, or square whose side is one centimeter long.

The *square millimeter*, or square whose side is one millimeter long.

The meter contains ten decimeters; but the square meter contains one hundred square decimeters, as may be readily seen by the figure, in which each side is divided by ten equidistant points connected by lines with the corresponding points on the opposite side. By this process, the square meter is divided into one hundred equal squares which are one decimeter long on each side, and, consequently, are so many square decimeters.

So, also, a decimeter contains ten centimeters, and a centimeter contains ten millimeters; but a square decimeter contains one hundred centimeters, and a square centimeter contains one hundred square millimeters.

Thus a square meter contains:

100 square decimeters.
10,000 square centimeters.
1,000,000 square millimeters.

In accordance with this principle, if we wish to represent decimally a surface composed of several square meters and several square decimeters, — for example, 8 square meters and 6 square decimeters, — we should write $\overset{m.}{8}.\,\overset{c.}{0}6$; because the square decimeter is the hundredth part of a square meter. So, also, to represent decimally a surface composed of 48 square meters, 6 square decimeters, and 4 square centimeters, we should write $4\overset{m.}{8}.\,0\overset{c.}{6}04$, because the square centimeter is the ten thousandth part of a square meter.

LAND MEASURE.

The square meter and its subdivisions suffice for every-day purposes. Larger measures than the square meter are seldom used, except for measuring land. They are then called *Land Measures.* They are:

The *Are*, a square whose side is 1 dekameter long, thus containing 100 square meters, just as the square meter contains 100 square decimeters.

The *Hectare*, a square whose side is 1 hectometer long, thus containing 100 ares. Its surface is equal to 10,000 square meters.

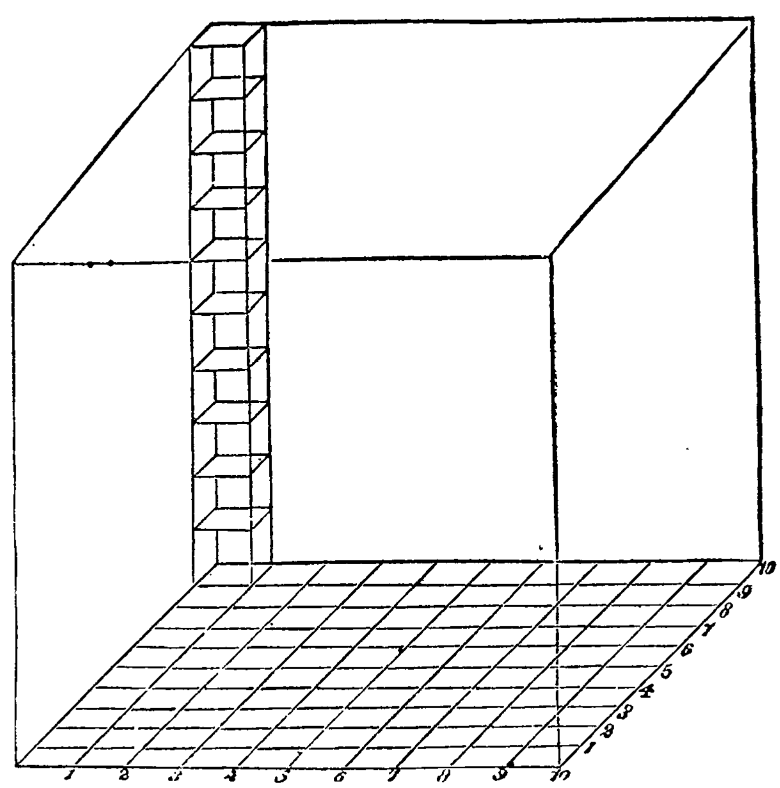
The only subdivision of the are is the *centiare,* or square meter, the one hundredth part of the are.

The reader will perhaps ask why there is no *deciare,* or *dekare* (the tenth of an are, and ten ares). The answer is, that the decimal order has been applied to the length of the sides of the squares. For example, the sides of the three squares — the *centiare,* the *are,* and the *hectare* — are in length, respectively, 1 meter, 1 dekameter, and 1 hectometer; and their surfaces are, respectively, 1 square meter, 100 square meters, and 10,000 square meters; and thus increase from a hundred to a hundred times greater. Therefore, in squares, we cannot have *deciares* and *dekares,* which would belong to the decimal order.

If, on the contrary, the decimal order had been applied to the *surfaces,* the sides of surfaces ten meters square and 1000 meters square could not have been expressed with precision in decimals; and in order to obtain them, it would have been necessary to extract the square root.

In fact, take ten small squares, and try to combine them in a single equivalent one, and you will fail; for if you place three of the small squares to serve as a side of the larger square, one will be excluded; if you place two, six will be excluded. You cannot, then, form a large square with ten small squares.

MEASURES OF VOLUME.



THE CUBIC METER,

SHOWING HOW IT IS COMPOSED OF CUBIC DECIMETERS, WHICH MAY BE DESCRIBED AS LYING IN THEIR SLICES, EACH CONSISTING OF 100 CUBIC DECIMETERS.

A CUBE is a geometrical figure shaped like a die. Its six faces are squares of the same size.

The *cubic meter* is a cube whose six faces are each a square meter.

The *cubic decimeter* is a cube whose six faces are each a square decimeter

The *cubic centimeter* is a cube whose six faces are each a square centimeter.

The *cubic millimeter* is a cube whose six faces are each a square millimeter

A cubic meter contains 1,000 cubic decimeters. Recollect that the square meter contains 100 square decimeters. We can therefore divide a cubic meter into 100 narrow pieces, the base of each of which will be one square decimeter, and the height one meter, as may be seen by examining the figure at the head of this chapter. But if this height of one meter be divided into ten decimeters, we can make, with each of the narrow pieces, ten pieces, each of which will have a base of one square decimeter, and a height of one decimeter, and will consequently be cubic decimeters. Therefore there are 10 times 100, or 1,000 cubic decimeters in a cubic meter.

So, also, a cubic decimeter contains 1,000 cubic centimeters, and a cubic centimeter contains 1,000 cubic millimeters.

Therefore, a cubic meter contains:

1,000 cubic decimeters.
1,000,000 cubic centimeters.
1,000,000,000 cubic millimeters.

If it be desired to represent decimally a certain number of cubic meters and decimeters, one must remember that the cubic decimeter is the thousandth part of a cubic meter. Therefore, to represent 66 cubic meters and 3 cubic decimeters, we should write, $\overset{\text{cubic meters}}{66.\ 003}$. So, also, to write, in cubic meters, 48 cubic decimeters and 6 cubic centimeters, we should write $\overset{\text{cubic meters}}{0.048006}$, because the cubic centimeter is the millionth part of the cubic meter.

To measure the volume of a body is to ascertain how many times it contains the unit of the cubic meter, the cubic decimeter, or the cubic centimeter.

The rules which serve for measuring the volume of different bodies are taught in treatises on Geometry, following those which relate to the measurement of surfaces. For example, to measure a beam of $\overset{\text{m.}}{3.4}$ in length, by $\overset{\text{m.}}{0.4}$ in width and $\overset{\text{m.}}{0.2}$ in thickness, it is necessary to multiply these three numbers by each other, and we thus find the volume of the beam expressed by the number $\overset{\text{m.}}{0.272}$; that is to say, it contains 272 times the thousandth part of the cubic meter or 272 cubic decimeters.

DRY AND LIQUID MEASURES.

In the trade in liquids and dry articles, like wine, wheat, flour, barley, &c., the principal unit of measure is the cubic decimeter, which then takes the name of *Liter*. But the liter is not used in the shape of a cube Its shape is that of a cylinder whose capacity is a cubic decimeter.

The subdivisions of the liter are:

The *deciliter*, the tenth part of the liter.

The *centiliter*, the tenth part of the deciliter, and the hundredth part of the liter.

The measures larger than the liter are:

The *dekaliter*, containing 10 liters.

The *hectoliter*, containing 100 liters.

The *kiloliter*, containing 1,000 liters.

It is easy to compute, in cubic meters, decimeters, or centimeters, one of the multiples or one of the subdivisions of the liter.

For example, the deciliter is equal to one hundred cubic centimeters, for it is the tenth part of the liter, and the liter is a cubic decimeter containing 1,000 cubic centimeters. So, also, the milliliter, the thousandth part of the liter, is equivalent to a cubic centimeter, because the liter contains 1,000 cubic centimeters.

MEASURE FOR FIREWOOD AND LUMBER.

The cubic meter is the unit of measure for firewood. It then receives the name of *Stere.*

The only multiple of the stere is the *decastere.* The only subdivision of the stere is the *decistere.*

To compute large numbers, we count by steres or decasteres. Thus we should say: 3,000 steres, or 300 decasteres.

In France firewood is measured in a *crib.* The crib for measuring the stere should be one square meter on the bottom, and one meter in height.

To measure a double stere, the dealers have cribs of two square meters on the bottom.

WEIGHTS.

THE GRAM.

AFTER having determined tne new unit of length, from which measures for surface and volume are deduced, as I have just shown, the Commission deposited in the Archives a *Kilogram*, made of platinum, intended to serve as a model for weights.

This model weight was not chosen at a venture. In fact, it was made so as to represent the weight of that substance which is the most universally distributed over the globe, and the most easily obtained pure, that is to say, without an admixture of foreign matter. *This standard weighs the same as a cubic decimeter of distilled water, in a vacuum, at the temperature of* 4 *degrees of the Centigrade thermometer.*

I say in a vacuum, and at the temperature of 4 degrees. These two points demand explanation.

In the first place, the pressure of the atmosphere being exerted in all directions on the surface of a body, the weight of that body is less by an amount equal to the weight of the atmosphere which the body displaces. That amount, then, necessarily varies with the very condition of the atmosphere, and the same body weighs differently at different times, because the air does not always exert an equal pressure. Hence, to obtain the actual weight of a body, it should be weighed in a vacuum ; because the removal of the atmosphere, which has the effect of buoying up an object, prevents diminution of its weight. In the vacuum a body also becomes independent of variations in the atmosphere.

In the second place, the particles composing bodies vary in distance from each other according to the temperature. Heat separates them, and cold draws them together; so that, according to the temperature, the same object, a cubic decimeter, for examplé, will contain more or less water, which, therefore, will weigh more or less. So, to secure a cubic decimeter of water of uniform weight, it must be weighed at the same temperature.

The temperature of 4 degrees has been chosen because (and it is a very remarkable characteristic of water) the contraction which takes place among the particles of water, in proportion as it becomes colder, ceases at that temperature, and changes to expansion. At that temperature the condition of water is termed its point of maximum density.

It is now evident why I said that *the standard weight for the platinum kilogram deposited in the Archives weighs the same as a cubic decimeter of distilled water, in a vacuum, at the temperature of 4 degrees of the centigrade thermometer*

The thousandth part of the platinum standard deposited in the Archives is called a *Gram;* and as there are a thousand cubic centimeters in a cubic decimeter, it follows that *the gram is the weight of a centimeter of distilled water, in a vacuum, at the temperature of* 4 *degrees of the centigrade thermometer.*

The subdivisions of the gram are the *decigram,* the *centigram,* and the *milligram.* The multiples of the gram are the *dekagram,* the *hectogram,* the *kilogram,* and the *myriagram.*

Each of these represents the weight of a determinate volume of water. Thus the dekagram is the weight of 10 cubic centimeters of distilled water; the hectogram that of 100 cubic centimeters of distilled water; the kilogram that of 1,000 cubic centimeters, or 1 cubic decimeter of distilled water.

RELATION OF THE DIFFERENT PARTS OF THE METRIC SYSTEM.

COMPARISON OF THE WEIGHT AND VOLUME OF WATER.

THE liter is a cubic decimeter; the gram weighs one cubic centimeter. Therefore, the kilogram, or 1,000 grams, weighs 1,000 cubic centimeters of water, which is a cubic decimeter of water. Hence the liter of water weighs a kilogram.

Hence also a cubic meter of water weighs 1,000 kilograms.

EXERCISES.

Ques. What is the weight of water contained in a vessel of the capacity of 35 liters?

Ans. 35 kilograms.

Ques. What is the weight of water contained in a cask of $\overset{\text{h.}}{2}.\overset{\text{l.}}{40}$? *

Ans. $\overset{\text{h.}}{2}.\overset{\text{l.}}{40}$ are the same thing as 240 liters; therefore the water which they would contain would weigh 240 kilograms.

* The letters *h*, *k*, *l*, *g* stand respectively for hectoliter, kiloliter, liter, and gram.

Ques. What is the weight of a cask of claret of $\overset{\text{h.}}{2}.\overset{\text{l.}}{4}0$, assuming the specific gravity of claret to be 0.9939, that of water being 1?

Ans. As the weight of the water would be 240 kilograms, by multiplying 0.9939 by 240, we would find the weight of the claret, $2\overset{\text{k.}}{3}8.5\overset{\text{g.}}{4}6$.

Ques. What is the weight of Burgundy contained in a cask of the same size as the last-mentioned, assuming the specific gravity of Burgundy to be 0.9915, that of water being 1?

Ans. $2\overset{\text{k.}}{3}7.9\overset{\text{g.}}{6}0$.

THE LITER COMPARED WITH THE CUBIC METER, THE CUBIC DECIMETER, AND THE CUBIC CENTIMETER.

The liter is the thousandth part of the cubic meter, and is equivalent to 1,000 cubic centimeters, and to 1,000,000 cubic millimeters.

EXERCISES.

Ques. How many cubic centimeters do the dekaliter and hectoliter respectively contain?

Ans. The dekaliter is equal to 10 cubic decimeters, or 10,000 cubic centimeters.

The hectoliter is equal to 100 cubic decimeters, or 100,000 cubic centimeters.

Ques. How many cubic centimeters and cubic millimeters are contained in the deciliter, the centiliter, and the milliliter?

Ans. The deciliter contains 100 cubic centimeters, or 100,000 cubic millimeters.

The centiliter contains 10 cubic centimeters, or 10,000 cubic millimeters.

The milliliter contains 1 cubic centimeter, or 1,000 cubic millimeters.

THE SQUARE METER AND ITS SUBDIVISIONS COMPARED WITH THE ARE.

The are is a square which contains 100 square meters; the square meter is, therefore, the hundredth part of the are.

The square decimeter is the ten thousandth part of the are.

The square centimeter is the millionth part of the are.

The square millimeter is the hundred millionth part of the are.

EXERCISES.

Ques. What is the relation of the square meter to the hectare?

Ans. It is the ten-thousandth part of the hectare.

Ques. How many square centimeters are there in a centiare?

Ans. 10,000.

Ques. How many square meters are there in 27 hectares and 4 ares?

Ans. 270,400.

THE KILOMETER COMPARED WITH THE CIRCUMFERENCE OF THE EARTH.

The meter is the ten-millionth part of the fourth of the terrestrial meridian. Therefore, the distance from the pole to the equator, or the fourth of the terrestrial meridian, is 10,000,000 meters, or 10,000 kilometers; and the whole meridional circumference of the globe is 40,000,000 meters, or 40,000 kilometers.

EXERCISES.

Ques. How many kilometers are there in a terrestrial degree?

Ans. There are 360 degrees in the circumference of the globe; therefore a degree contains the $\frac{1}{360}$th part of 40,000 kilometers, or $\overset{k.}{111}.\overset{m.}{111}$.

Ques. How many kilometers are there in a distance of 3° 40′?

Ans. $\overset{k.}{407}.\overset{m.}{407}$.

Ques. The latitude of Paris is 48° 50′.

At the distance of how many kilometers from the equator is that city situated?

Ans. $\overset{k.}{5425}.\overset{m.}{92}+$.

TENTHS, HUNDREDTHS, ETC. OF THE SQUARE METER, AND OF THE CUBIC METER, COMPARED WITH THE SQUARE DECIMETER, AND THE CUBIC DECIMETER, ETC.

A square meter is equal to 100 square decimeters, 10,000 square centimeters, 1,000,000 square millimeters. Therefore, the tenth of a square meter is equal to 10 square decimeters, 1,000 square centimeters, 100,000 square millimeters.

The hundredth of a square meter is equal to 1 square decimeter, 100 square centimeters, 10,000 square millimeters.

The thousandth of a square meter is equal to 10 square centimeters, 1,000 square millimeters.

A cubic meter is equal to 1,000 cubic decimeters, 1,000,000 cubic centimeters, 1,000,000,000 cubic millimeters; therefore the tenth of a cubic meter is equal to 100 cubic decimeters, 1,000,000 cubic centimeters, 100,000,000 cubic millimeters.

The hundredth of a cubic meter is equal to 10 cubic decimeters, 10,000 cubic centimeters, 10,000,000 cubic millimeters.

The thousandth of a cubic meter is equal to one cubic decimeter, 1,000 cubic centimeters, 1,000,000 cubic millimeters.

EXERCISES.

Ques. What is the relation of 25 square decimeters to a square meter?

Ans. They are the fourth.

Ques. What is the relation of 15 square decimeters to a square meter?

Ans. They are $\frac{15}{100}$, or $\frac{3}{20}$ of a square meter.

Ques. What is the relation of 380 square centimeters to a square meter?

Ans. They are $\frac{380}{10,000}$, or $\frac{19}{500}$ of a square meter.

Ques. What is the relation of 25 cubic decimeters to a cubic meter?

Ans. Twenty-five cubic decimeters are $\frac{1}{40}$ of a cubic meter.

Ques. What is the relation of 15 cubic decimeters to a cubic meter?

Ans. Fifteen cubic decimeters are $\frac{15}{1000}$, or $\frac{3}{200}$ of a cubic meter.

Ques. A bottle contains 735 grams of water; what portion of a liter are they?

Ans. 0.737.

Ques. If sticks of firewood were 114 centimeters long (that was formerly the length of firewood in Paris), what would be the requisite dimensions of the crib to measure the stere?

Ans. 114 centimeters in length, 1 meter in width, and 88 (nearest decimal) centimeters in height.

Ques. If sticks of firewood were 130 centimeters long, what would be the requisite dimensions of the crib to measure the stere?

Ans. 130 centimeters in length, 1 meter in width, and 77 (nearest decimal) in height.